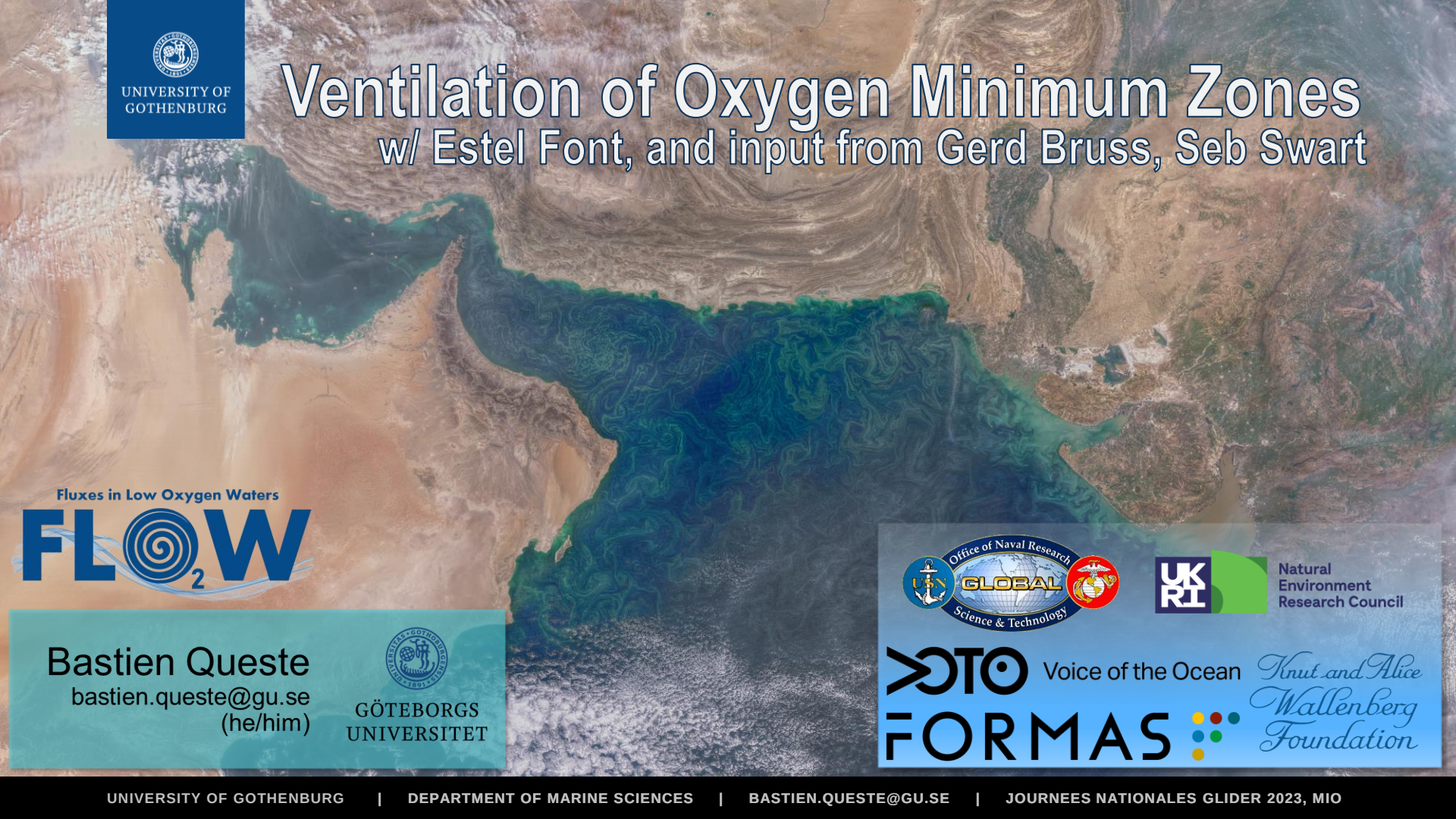


UNIVERSITY OF GOTHENBURG

Ventilation of Oxygen Minimum Zones

w/ Estel Font, and input from Gerd Bruss, Seb Swart

Fluxes in Low Oxygen Waters

FLO2W

Bastien Queste
bastien.queste@gu.se
(he/him)

GÖTEBORGS UNIVERSITET

Office of Naval Research Global Science & Technology

UKRI Natural Environment Research Council

Voice of the Ocean

FORMAS

Knut and Alice Wallenberg Foundation

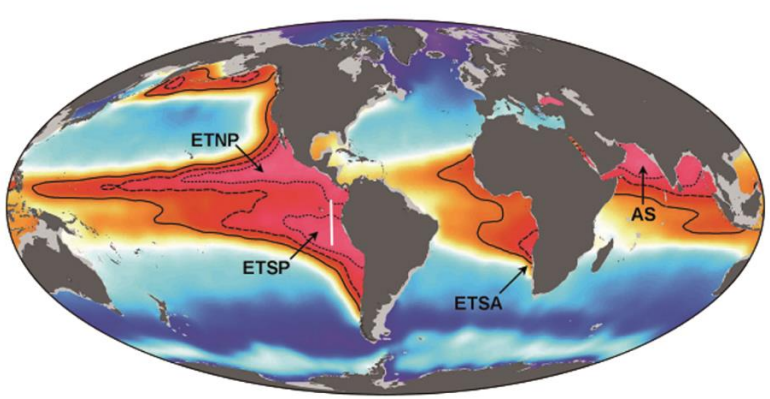


Fig 1: Ocean oxygen concentrations, in µM, at 300 m depth. Arrows indicate the location of the major oxygen minimum zones: the Eastern Tropical North Pacific, Eastern Tropical South Pacific, Eastern Tropical South Atlantic and the Arabian Sea. *Adapted from Breitburg et al. (2018).*

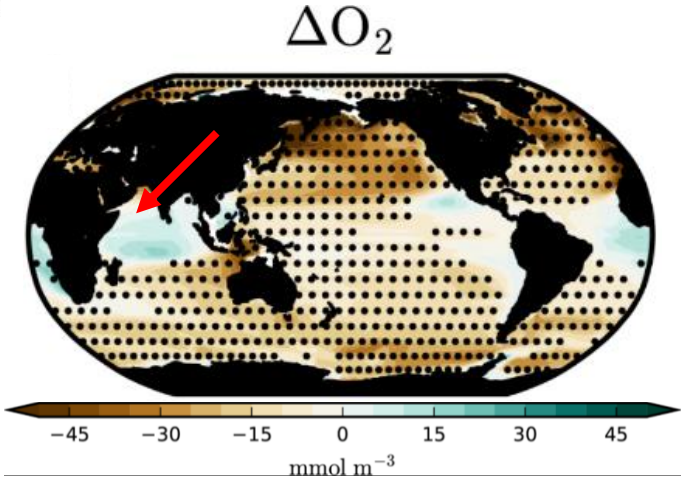


Fig 2: CMIP6 multi-model mean changes in subsurface oxygen concentration (100 - 600 m; mmol m^{-3}) in 2080–2099 relative to 1995–2014 of SSP5-8.5.
Stippling designates at least 80 % model sign agreement (only a subset of CMIP6 models were considered).
Kwiatkowski et al. (2020)

$$\frac{d[O_2]}{dt} = -u\frac{\partial[O_2]}{\partial x} - v\frac{\partial[O_2]}{\partial y} - w\frac{\partial[O_2]}{\partial z} + K_h\frac{\partial^2[O_2]}{\partial x^2} + K_h\frac{\partial^2[O_2]}{\partial y^2} + K_v\frac{\partial^2[O_2]}{\partial z^2} + BioChem([O_2])$$

Dual glider survey design

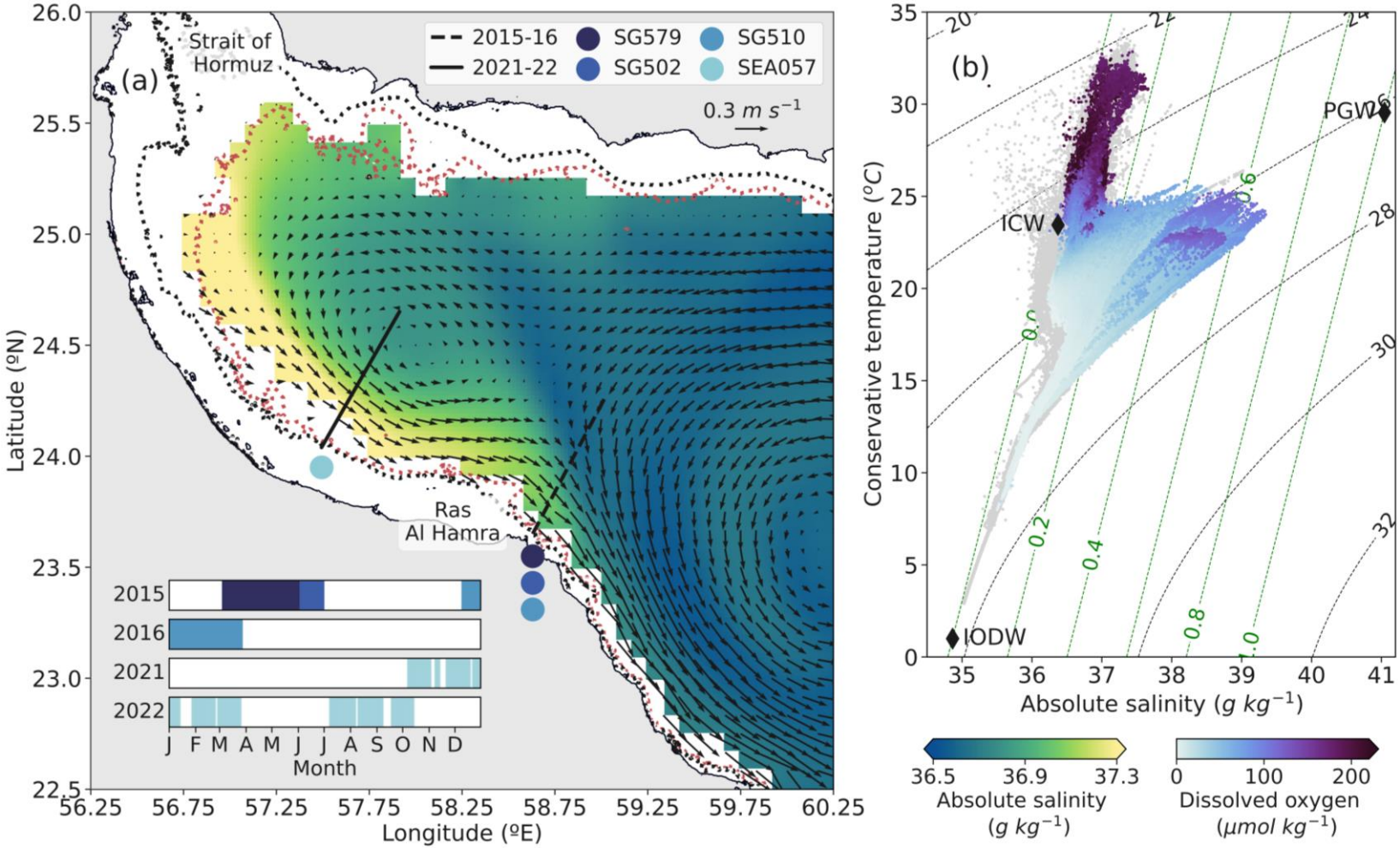
Physics - SEA057 "*King Tubby*":

- T, S, O_2
- Chl-a, PE, bb 700nm
- Microstructure turbulence
- ADCP

Biology – SEA070 *"Scratch"*:

- T, S, O_2
- Chl-a, CDOM, bb 700nm
- PAR + 3 wavelengths
- NO_x, H_2S

$$\frac{d[O_2]}{dt} = -u\frac{\partial[O_2]}{\partial x} - v\frac{\partial[O_2]}{\partial y} - w\frac{\partial[O_2]}{\partial z} + K_h\frac{\partial^2[O_2]}{\partial x^2} + K_h\frac{\partial^2[O_2]}{\partial y^2} + K_v\frac{\partial^2[O_2]}{\partial z^2} + BioChem([O_2])$$

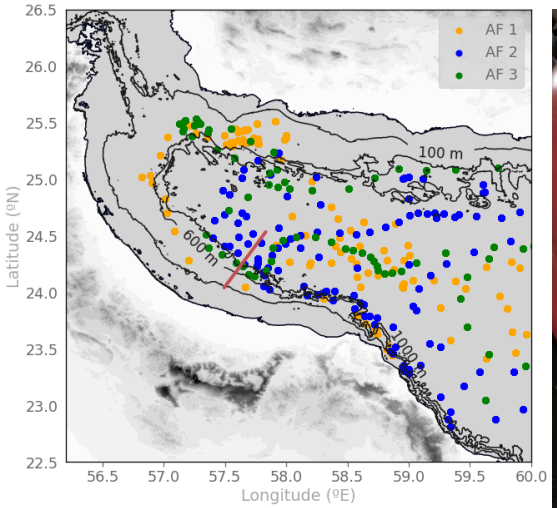

(a)
Strait of Hormuz
2015-16
2021-22
SG579
SG502
SG510
SEA057
0.3 m s⁻¹
Ras Al Hamra
2015
2016
2021
2022
J F M A M J J A S O N D
Month
Latitude (ºN)
Longitude (ºE)
26.0
25.5
25.0
24.5
24.0
23.5
23.0
22.5
56.25
56.75
57.25
57.75
58.25
58.75
59.25
59.75
60.25
(b)
PGW
ICW
IODW
Conservative temperature (ºC)
Absolute salinity (g kg⁻¹)
35
30
25
20
15
10
5
0
35
36
37
38
39
40
41
0.2
0.4
0.6
0.8
1.0
28
30
32
36.5
36.9
37.3
Absolute salinity
(g kg⁻¹)
0
100
200
Dissolved oxygen
(μmol kg⁻¹)

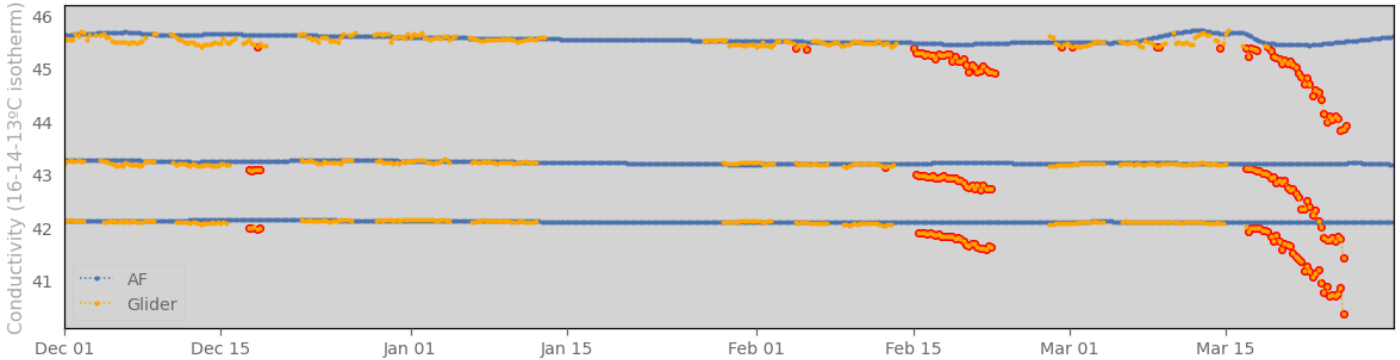
Biofouling limits platform usefulness long term

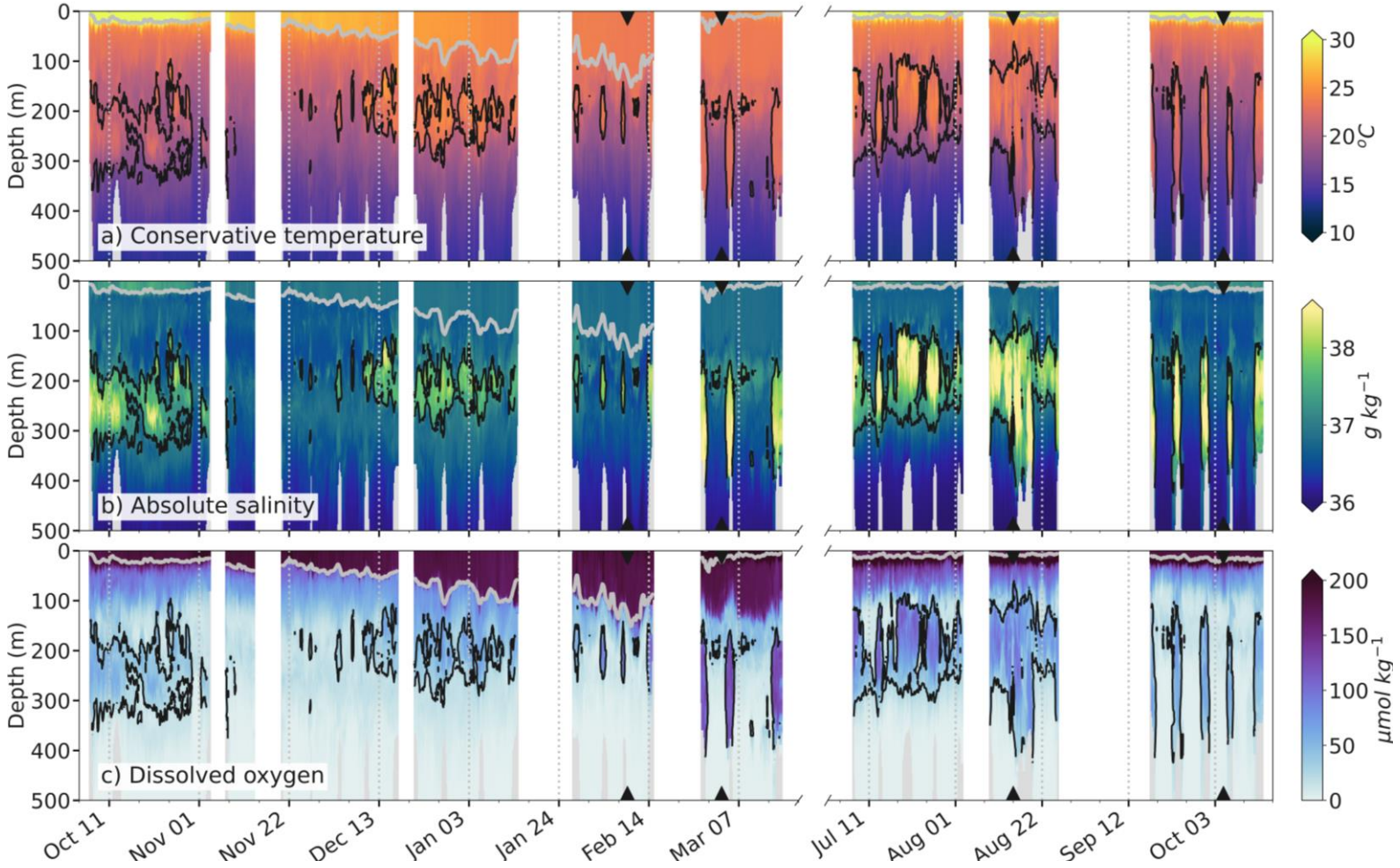
In high productivity periods (mainly spring and early summer), we observe very rapid growth of algae and bivalves on the glider, including in the CT cell.

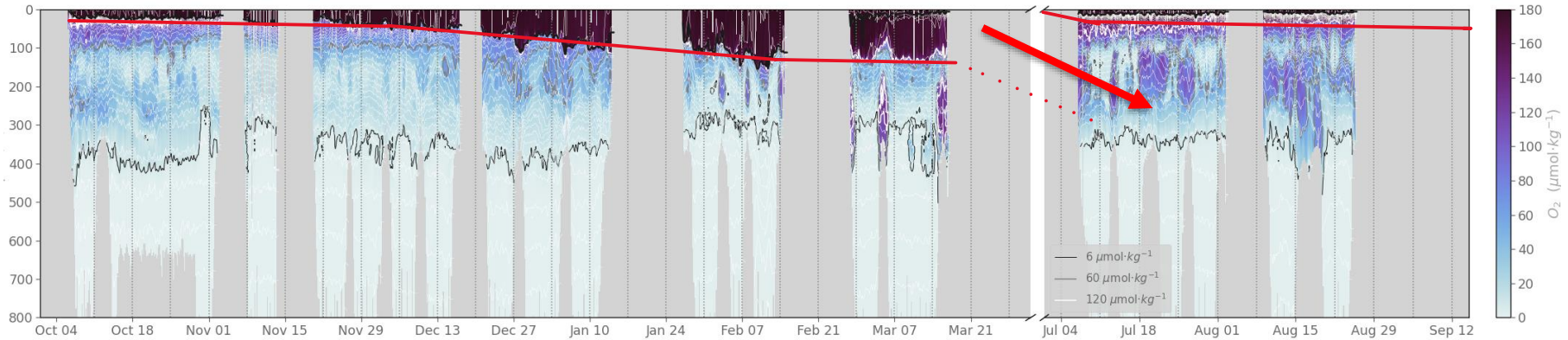
Longer endurance from primary lithiums would not be advantageous.

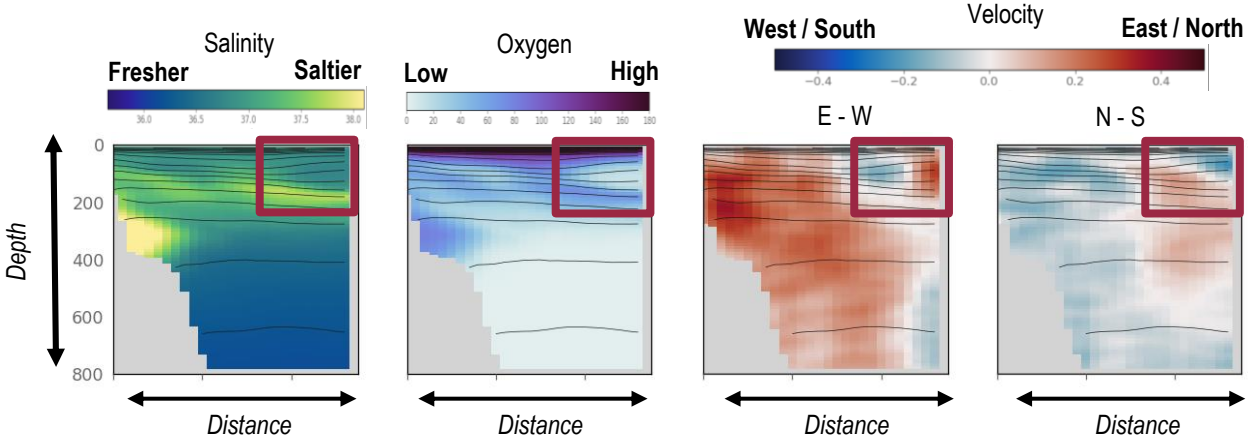
Correction of drift can be corrected to some extent using Argo float data.






Depth (m)
0
100
200
300
400
500
a) Conservative temperature
b) Absolute salinity
c) Dissolved oxygen
30
25
20
15
10
°C
38
37
36
g kg⁻¹
200
150
100
50
0
µmol kg⁻¹
Oct 11
Nov 01
Nov 22
Dec 13
Jan 03
Jan 24
Feb 14
Mar 07
Jul 11
Aug 01
Aug 22
Sep 12
Oct 03





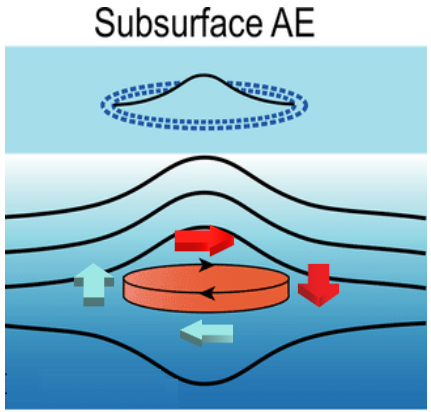


Figure adapted from Wang et al. (2019)

JGR Oceans

RESEARCH ARTICLE
10.1029/2021JC018045

Key Points:
- Ocean glider observations reveal

Seasonal to Intraseasonal Variability of the Upper Ocean Mixed Layer in the Gulf of Oman

Estel Font[1], Bastien Y. Queste[1], and Sebastiaan Swart[1,2]

Total heat flux

Q_{NET}

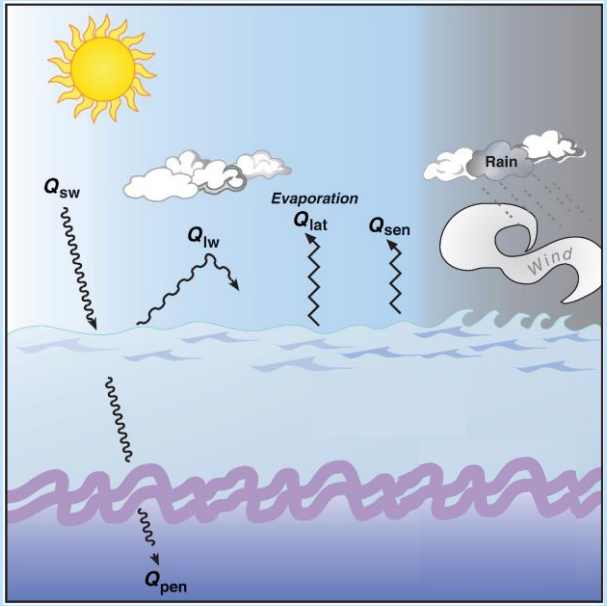


Figure adapted from: Cronin et al. (2001)

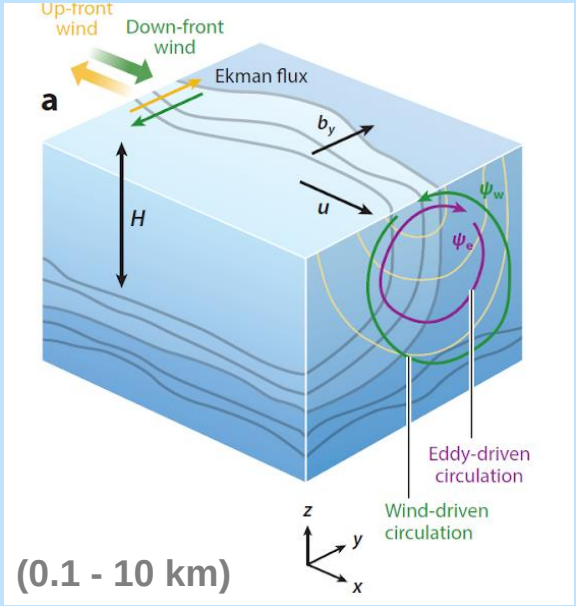


Figure adapted from: Mahadevan et al. (2016)

Submesoscale Processes

Q_{SMS}

Mixed layer eddies (MLE)

Ekman buoyancy flux (EBF)

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Key Points:

- Ocean glider observations reveal

Q_{SMS} primarily contribute to stratify the winter ML accounting for :
68% of the total positive heat budget
& opposing surface cooling **11% of the time**

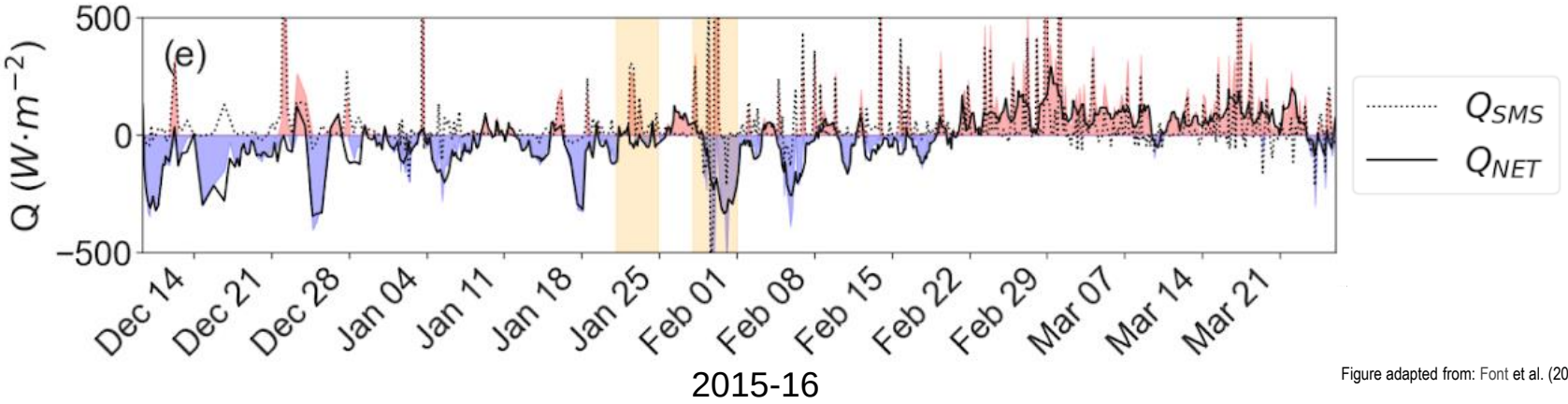
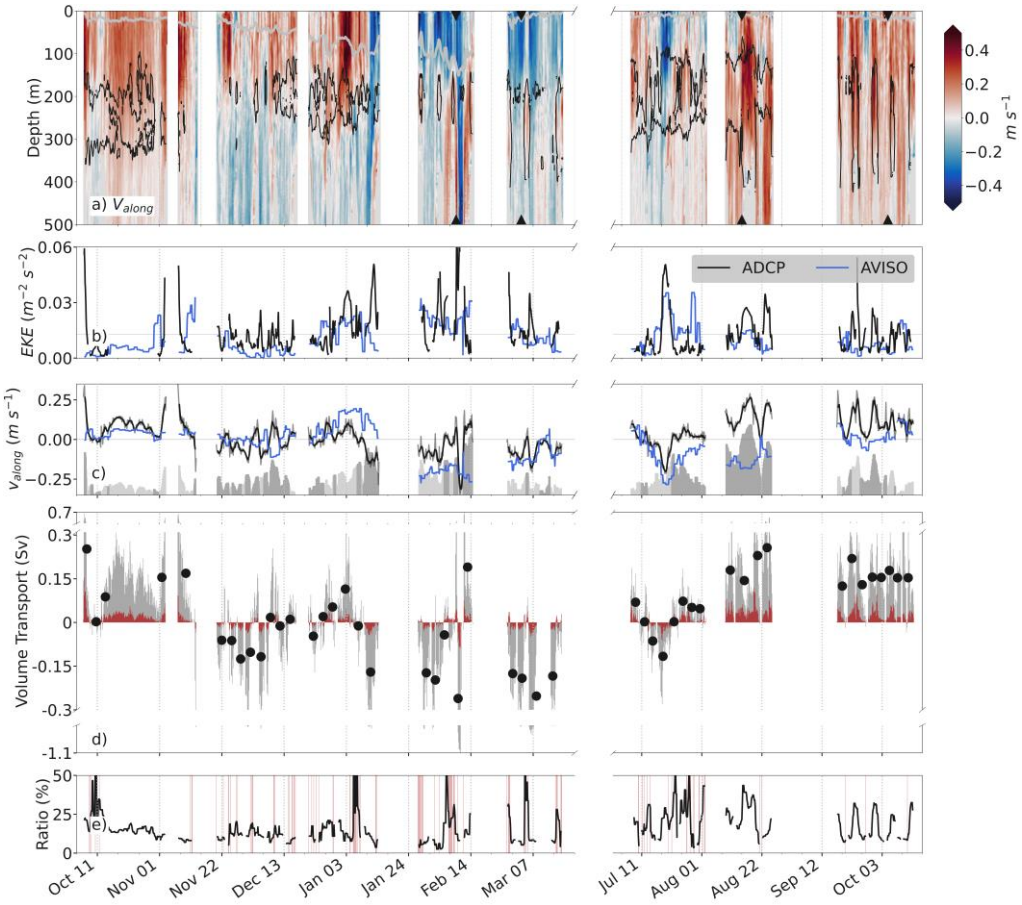


Figure adapted from: Font et al. (2022)



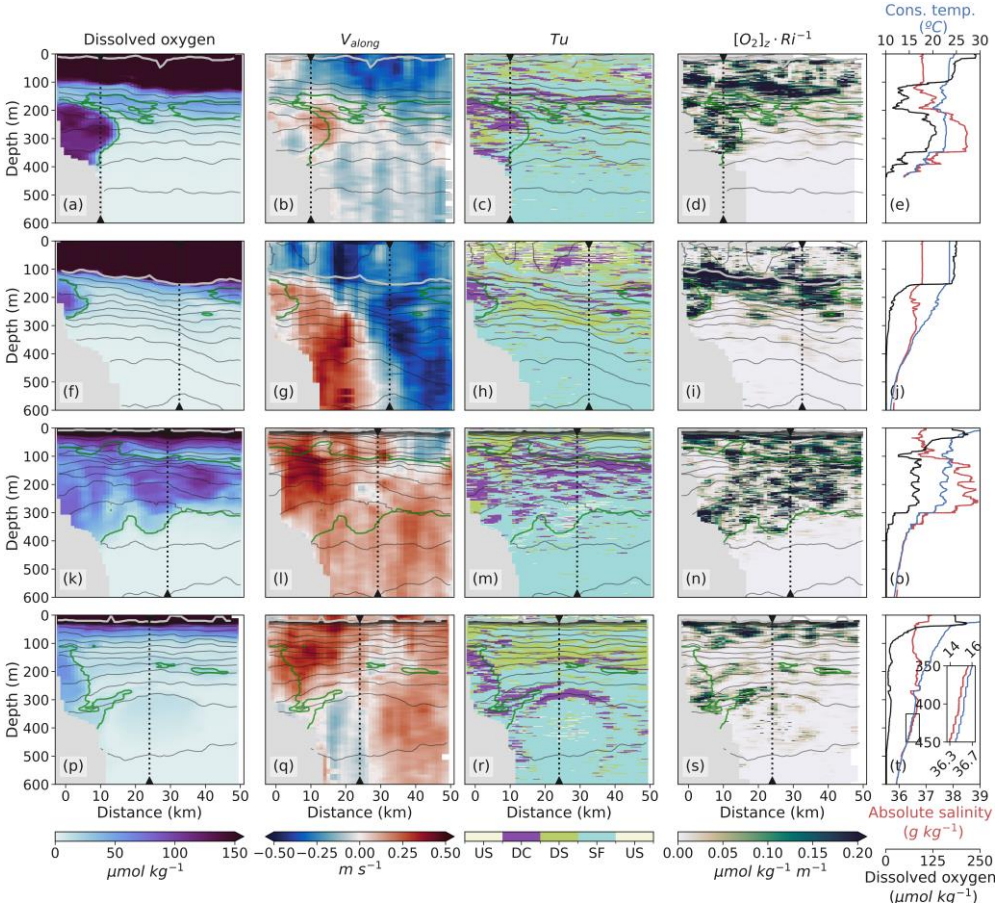
Ventilation of the Arabian Sea Oxygen Minimum Zone by Persian Gulf Water

Estel Font [1], Sebastiaan Swart [1,2], Gerd Bruss [3], Peter M.F. Sheehan [4], Karen J. Heywood [4], and Bastien Y. Queste [1]

Key Points:

- PGW is characterized by high spatiotemporal variability in its properties and transport that impacts the variability of the upper OMZ.
- Oxygen contribution from PGW to the Arabian Sea OMZ is resolved for the first time as 1.3 Tmol yr^{-1}.
- Intermittent shear-driven mixing at the PGW bottom boundary amplifies ventilation of the OMZ by salt fingering 14% of the time.

Estimations du melange a valider avec le MR...



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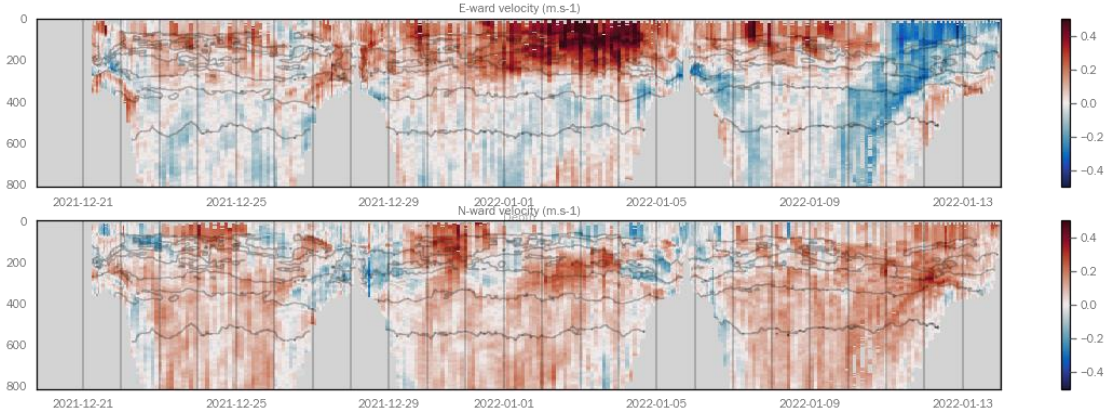

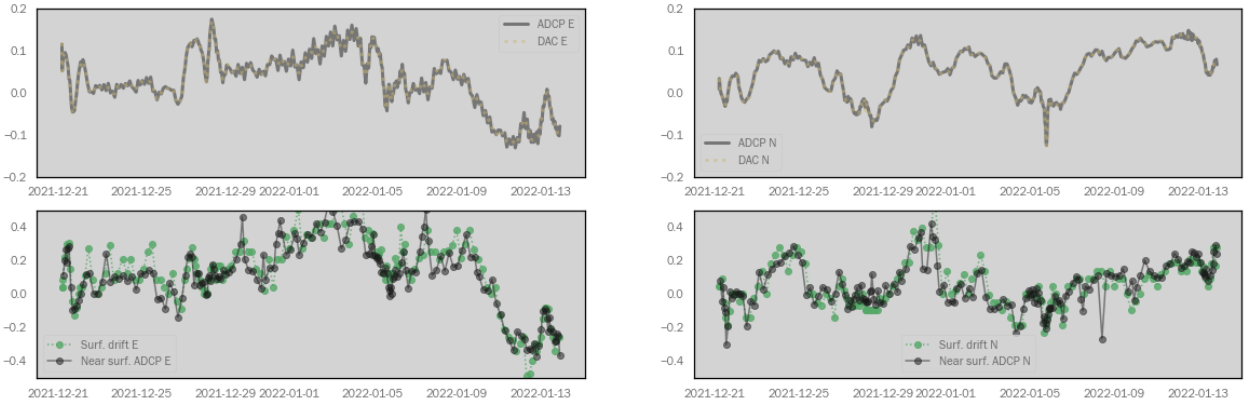

gliderad2cp: A Python package to process Nortek AD2CP velocity profiles from gliders

Bastien Y. Queste [1,2*¶], **Callum Rollo** [2*], **and Estel Font** [1]

1 Department of Marine Science, University of Gothenburg, Natrium, Box 463, 405 30 Göteborg, Sweden 2 Voice of the Ocean Foundation, Skeppet Árans väg 3, 426 71 Västra Frölunda, Sweden ¶ Corresponding author * These authors contributed equally.

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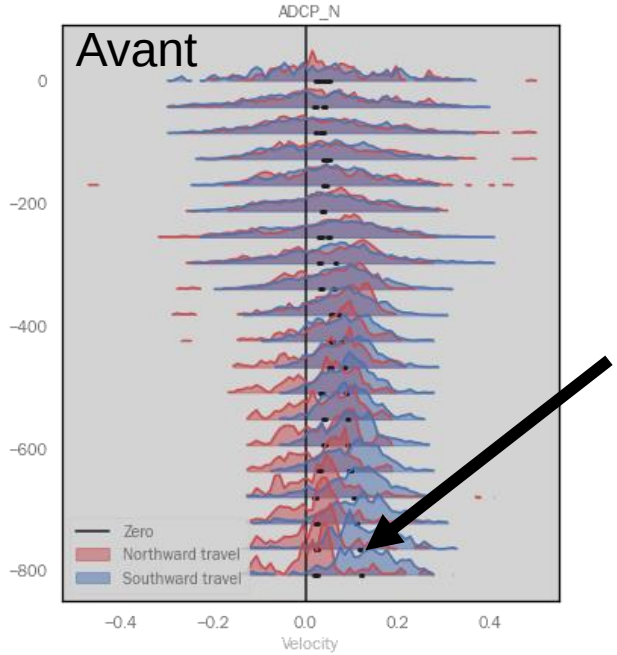

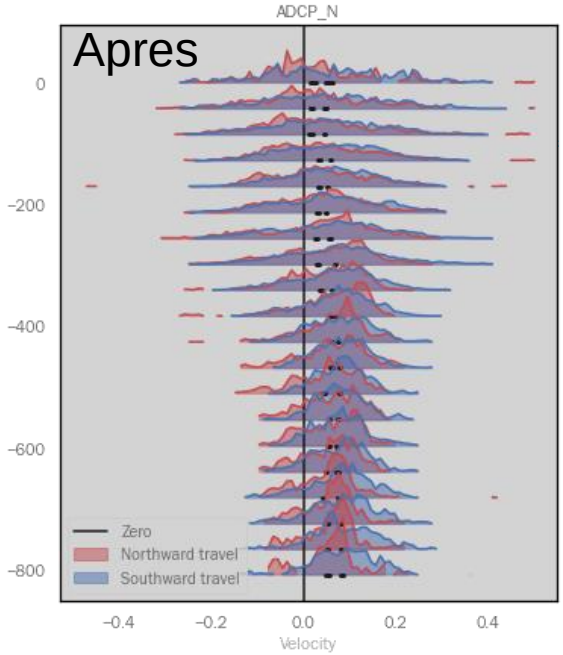

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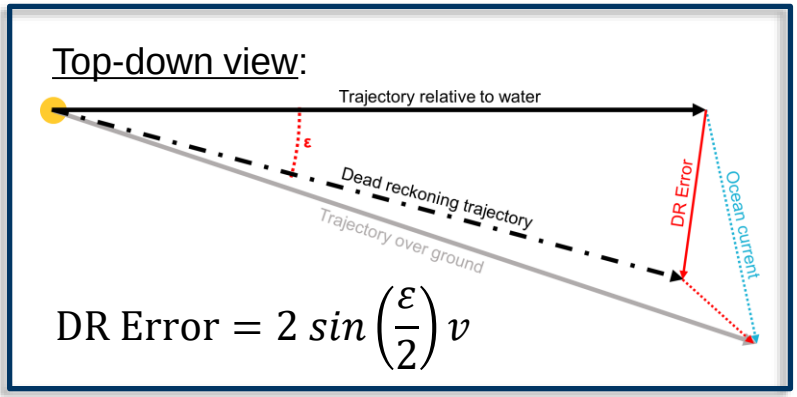
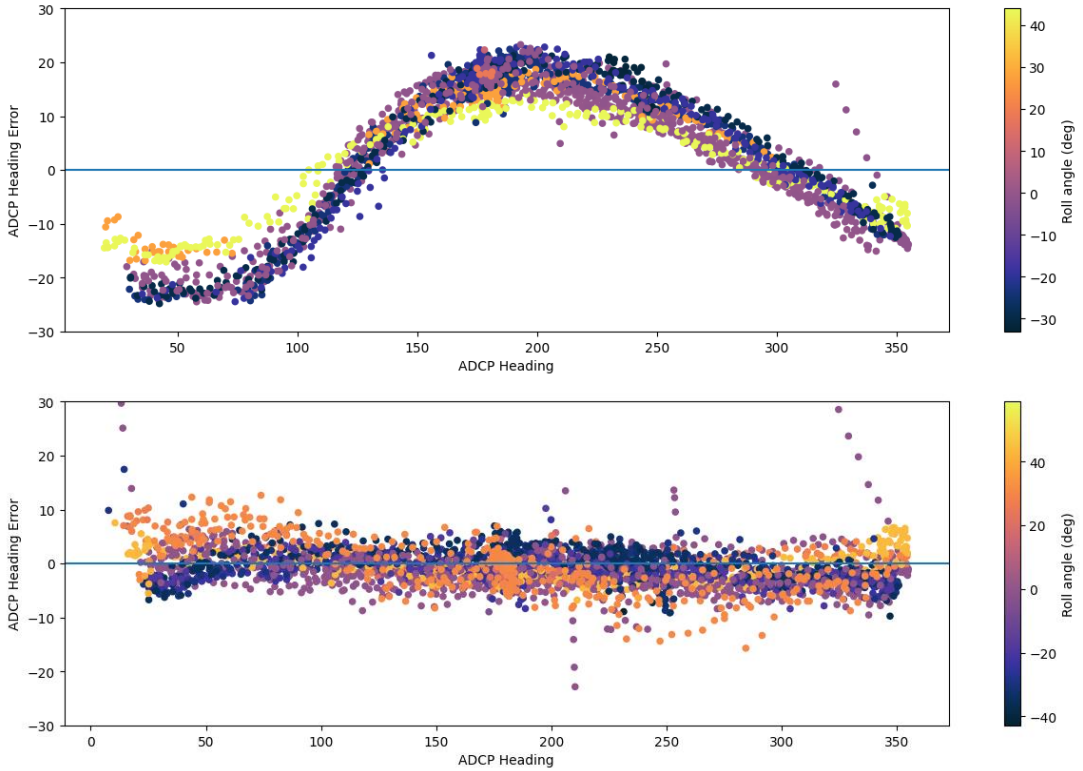
Refining magnetometry for accurate current calculations





Assuming a horizontal speed of 40 cm.s^{-1}, heading errors of (1, 5, 10, 20) degrees can lead to dive-averaged current errors of (0.7, 3.5, 7, 13) cm.s^{-1} respectively.

Key progress :

ADCP processing ☑
Compass calibration ☑
Horz. Advection ☑
Mixed layer pump in progress…
MR1000-G in progress…
PP/Respiration – help please?

- Dual compass mission?
- Noisy legato 16Hz?
- Biofouling tips?
- Acoustic backscatter for zoo/mesoplankton?

Welcoming new PhD, Mauro Pinto, on January 10th.

UNIVERSITY OF GOTHENBURG

Fluxes in Low Oxygen Waters

FLO2W

Polar gliders

Sultan Qaboos University

Office of Naval Research Global Science & Technology

UKRI Natural Environment Research Council

OTO Voice of the Ocean

FORMAS

Knut and Alice Wallenberg Foundation

Biological unknowns: biological extreme events

Primary production

→ Knowledge through remote sensing. Points of failure include deep productivity, coastal waters, resolution and clouds.

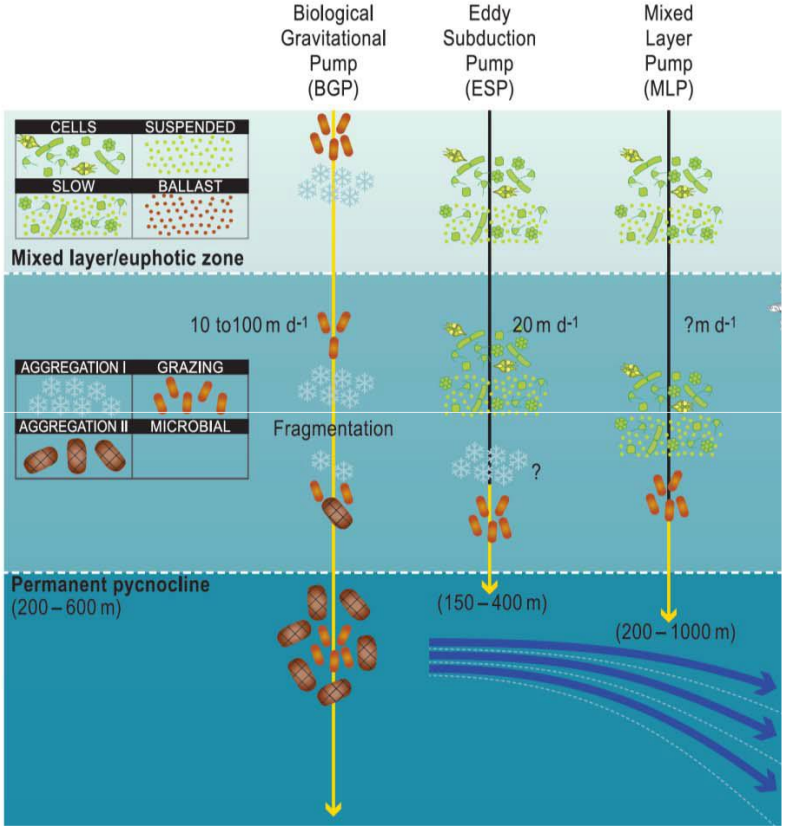
Mixed layer depth variability

→ State less importance than *d*MLD/*dt*. Changes are rapid (hours!) and heterogenous.

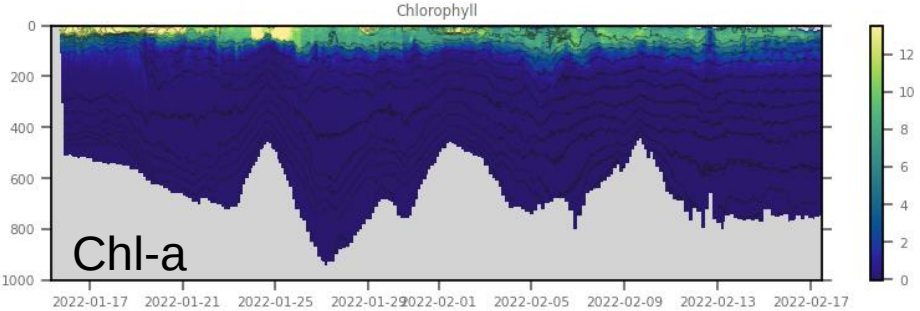
→ Mixing remains a huge uncertainty

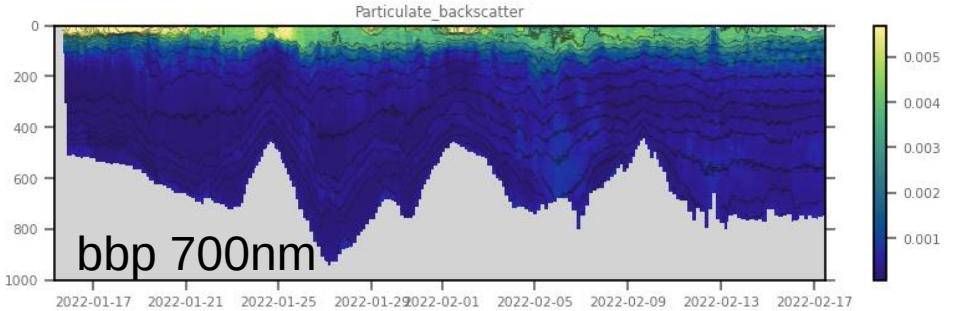
Particulate sinking and carbon export

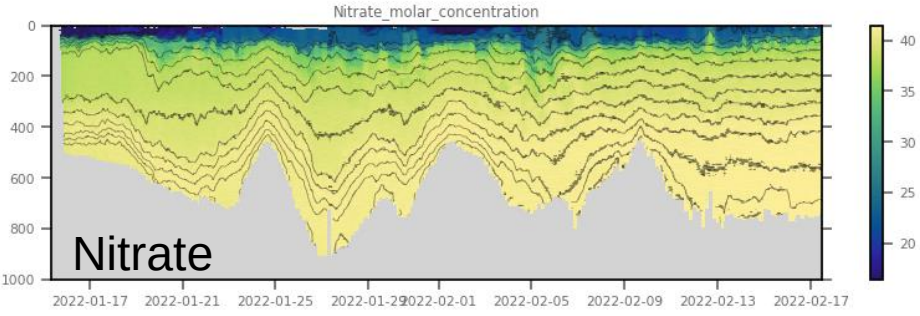
→ Subsurface, both physics and biology driven, very poorly understood and very sporadic.

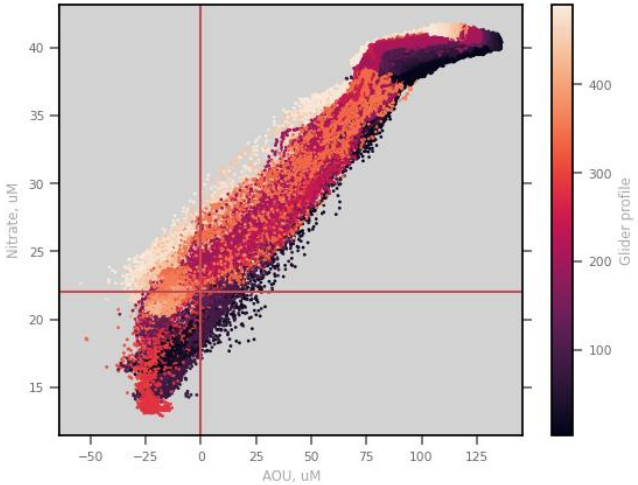


Estimating export and remineralisation (Antarctica)









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